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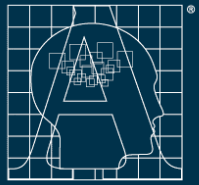
Improving Human-Automation Interaction for Unmanned Vehicle Mission Planning

Mike Linegang, Heather Stoner, Mike Patterson

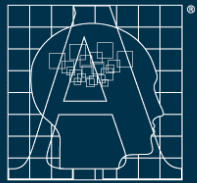
06/07/2006

Project Collaborators

John Lee, Bobbie Seppelt, Josh Hoffman, Zach Crittendon, Mike Polidoro

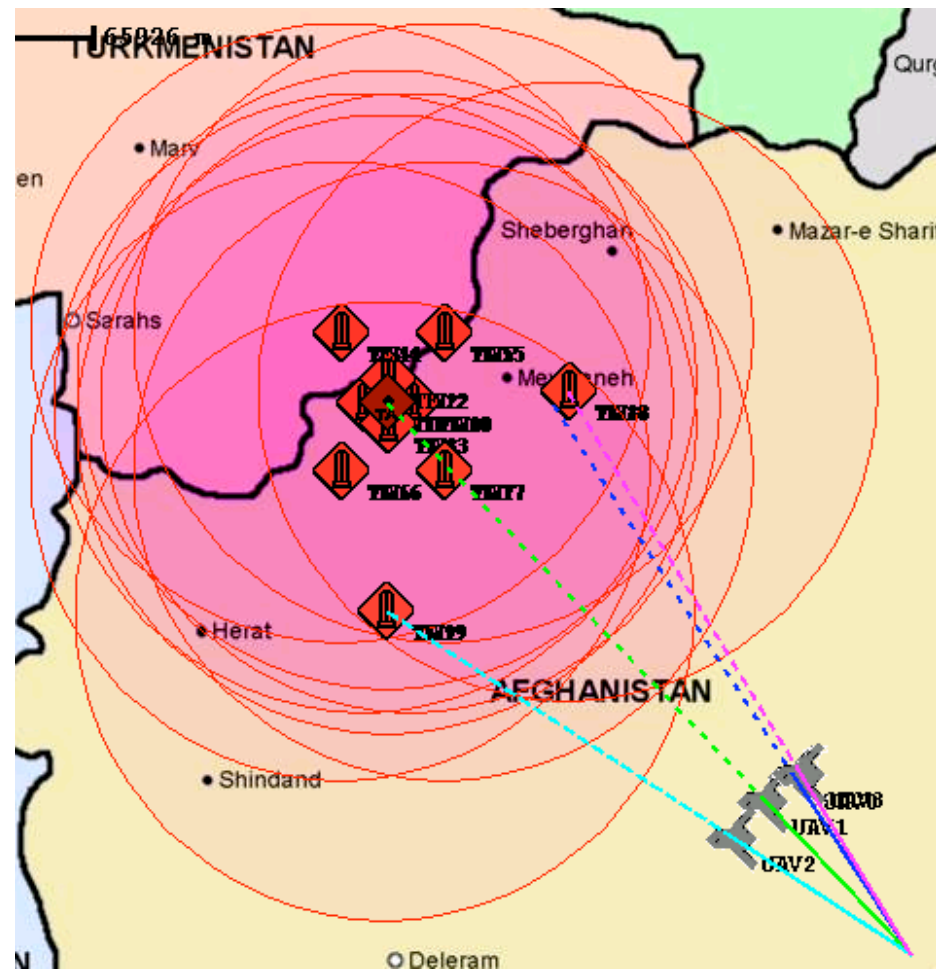


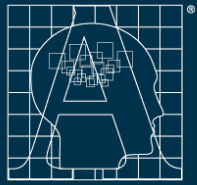
- FNC Autonomous Operations
 - Intelligent Autonomy Program has developed automated mission planning & execution technologies
 - Optimal path planning for UAV, UUV, and USV systems conducting Intelligence, Surveillance, and Reconnaissance
 - Dynamic task allocation w/ limited communication availability
 - Human SME's have had difficulty understanding & diagnosing complex plans produced by automation
 - Plans are often quite good (once SME's can understand)
 - ...but plans are sometimes NOT good
 - The lack of understandable, diagnosable plans makes it impossible for humans and automation to collaborate
 - Humans can't develop any trust for the automation



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Good Plan? Bad Plan?



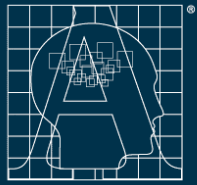


Problem Statement

Develop innovative mission plan understanding / assessment tools that will enable a mission manager of multiple heterogeneous unmanned vehicles to rapidly judge the value of plans developed by autonomous systems, choose between plan options, and **understand how best to** modify plans to **achieve high-level tactical goals**.

-Objective statement from N05-T017 STTR solicitation

*To agree upon the PLAN,
you need to discuss the MISSION*



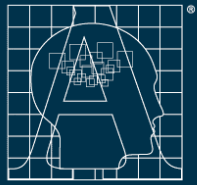
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The Display Design Challenge

Simple Display
(Limited Data)
(Loss of SA)

Complex Display
(Too Much Data)
(Loss of SA)



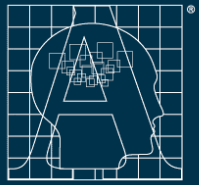


*Developing innovative mission plan understanding / assessment tools that will enable a mission manager of multiple heterogeneous unmanned vehicles to rapidly judge the value of plans developed by autonomous systems, choose between plan options, and **understand how best to** modify plans to **achieve high-level tactical goals**.*

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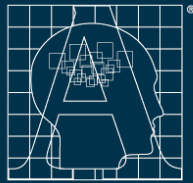
*Creating an interface that presents a **simple enough** view for a Human to understand and evaluate...*

*... but **rich enough** to reveal the subtleties in an automation-generated plan.*

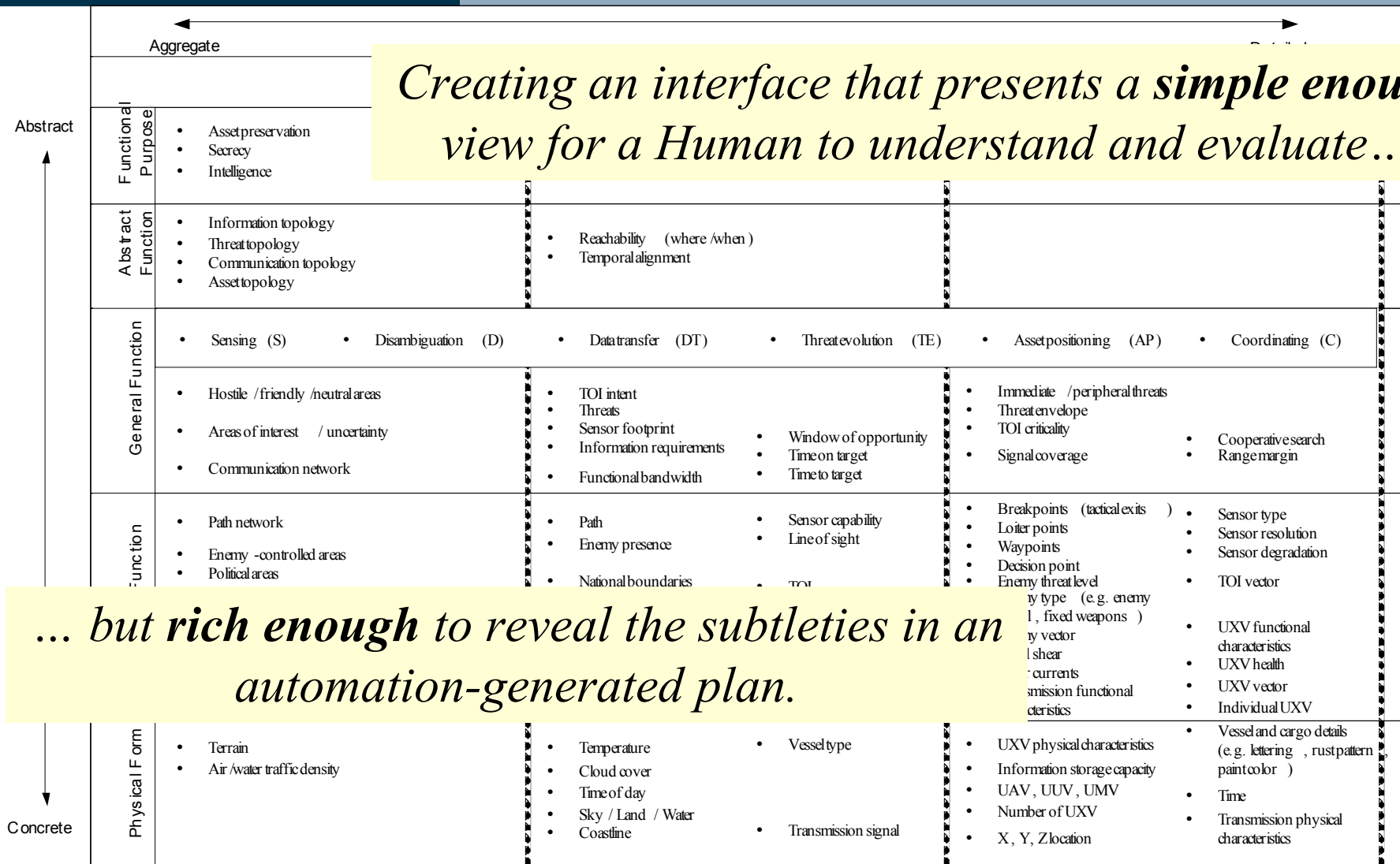


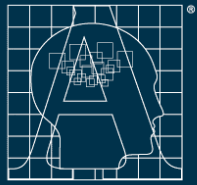
Overview of MiDAS

- Rich, but simple displays present lots of data, but **present it in an organized manner**
 - MiDAS organizes the data around stable properties of missions
- Phase I STTR results
 - Detailed mapping of Littoral ISR mission information structure
 - Conceptual presentation of information in decomposable clusters
- Phase II STTR plan
 - Formally define Littoral ISR mission information structure
 - Operationalize decomposable information clusters in software



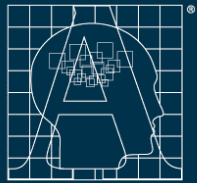
Work Domain Analysis



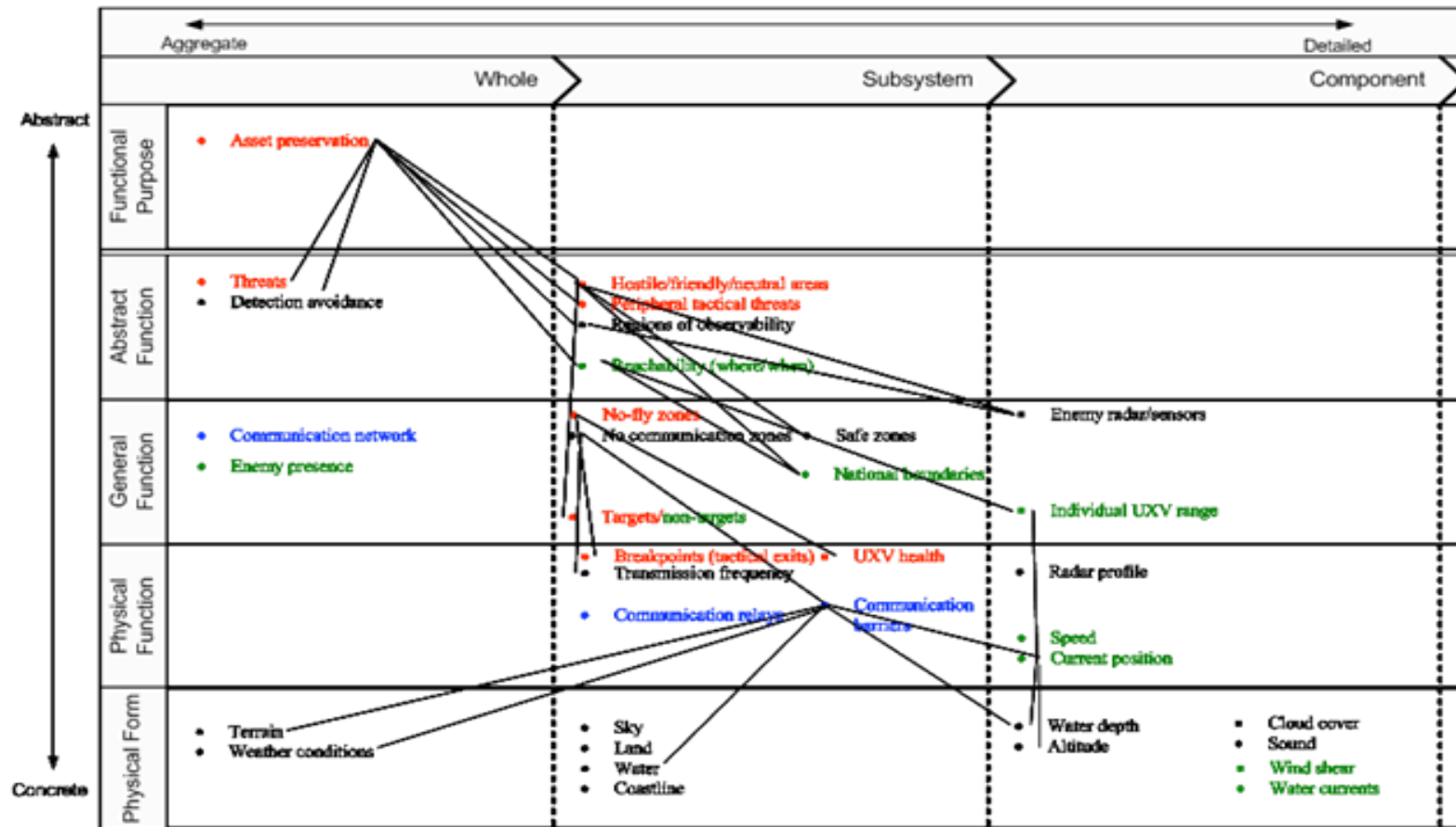


Simplifying Command and Control

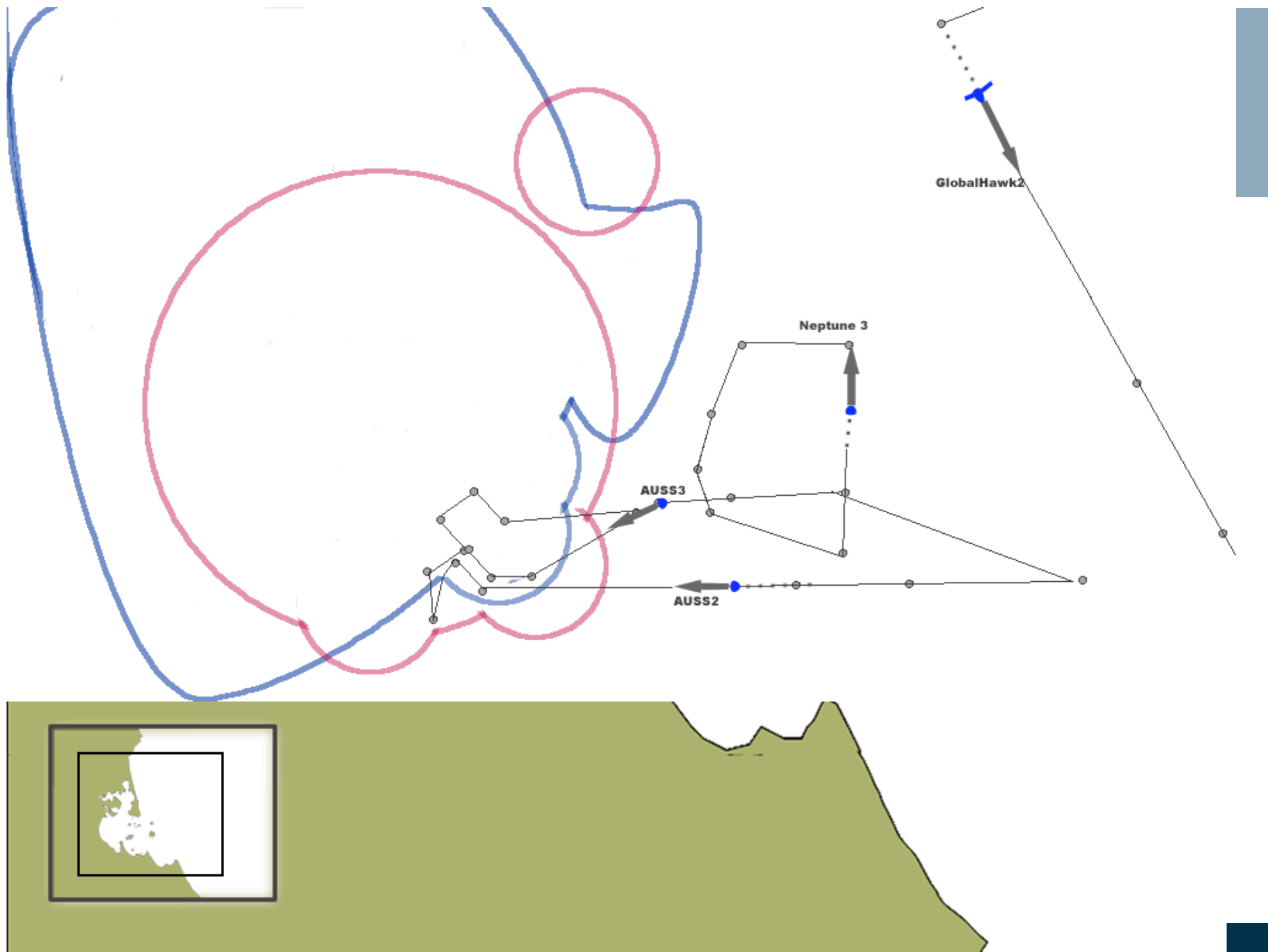
- Dynamic systems seek to achieve a balance amongst some small set of competing factors
 - If we can display the tension between those factors, we have a simple, yet powerful method for organizing C2 information
- C2 for Littoral ISR Missions requires the “planner” to balance 3 competing demands:
 1. Gather **Intelligence**
 - Match information collection devices with information collection objectives in time and space
 2. Maintain **Secrecy** of the mission
 - Keep friendly assets in positions that will avoid detection
 3. Preservation of friendly assets (**Asset Preservation**)
 - Keep friendly assets in positions that avoid damage, destruction, or loss of asset capabilities

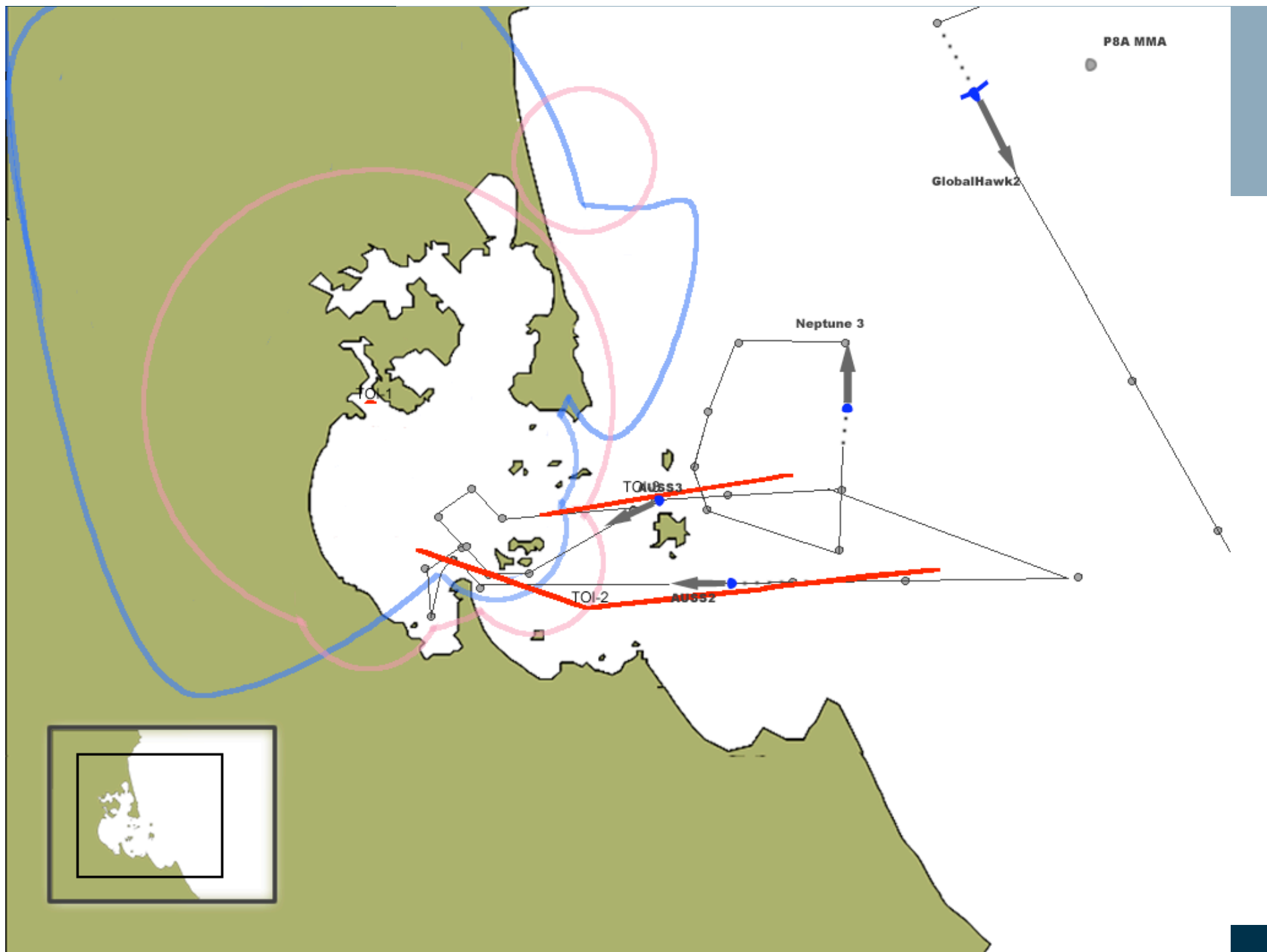


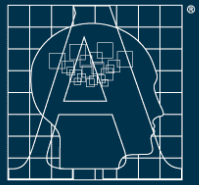
Clustering Information



- Defining formal relationships between low-level data and higher-level concepts will support effective clustering of information on a display

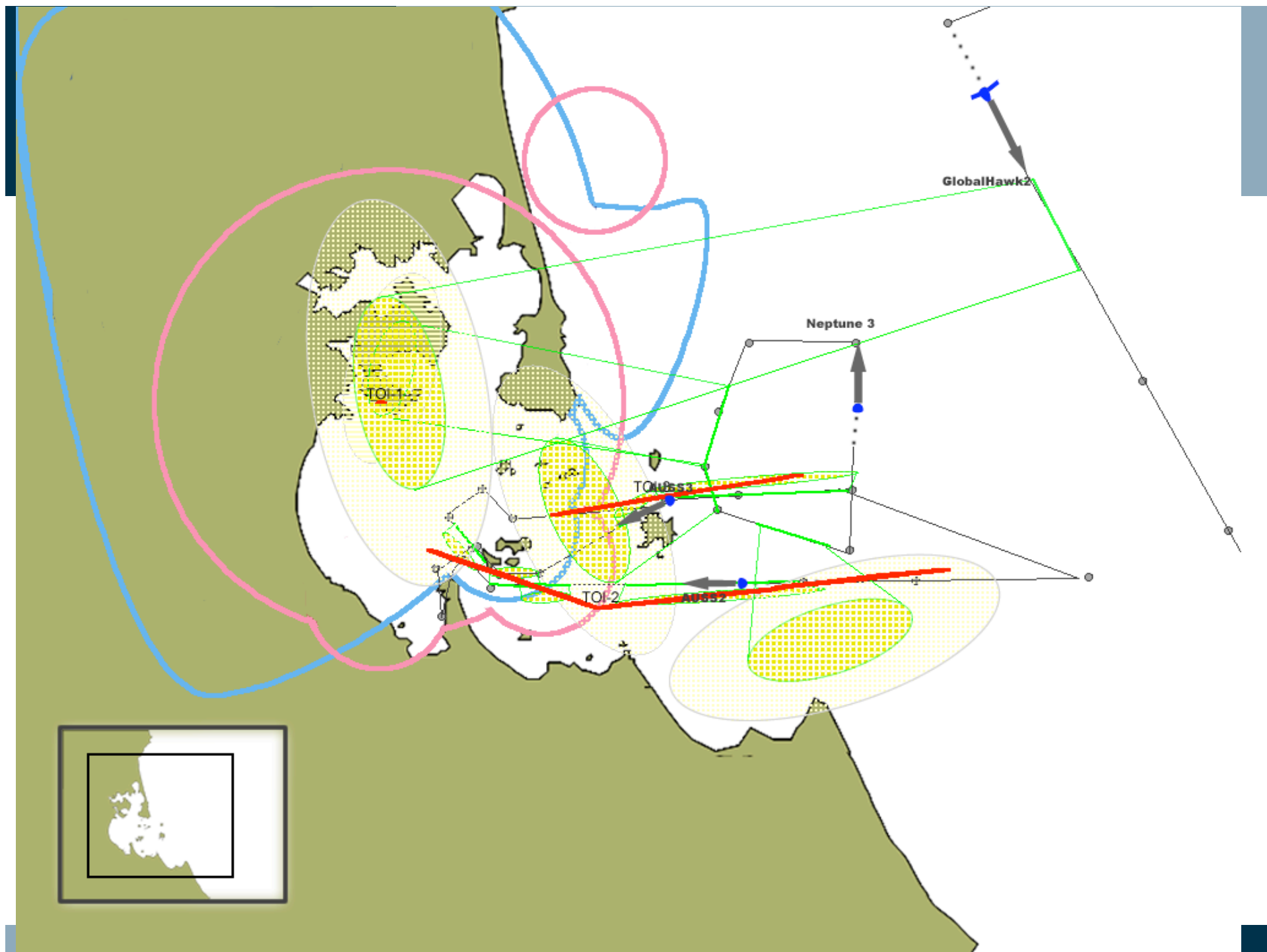


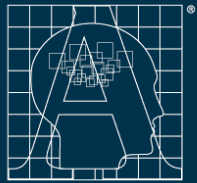




Representing Tension between Competing Factors

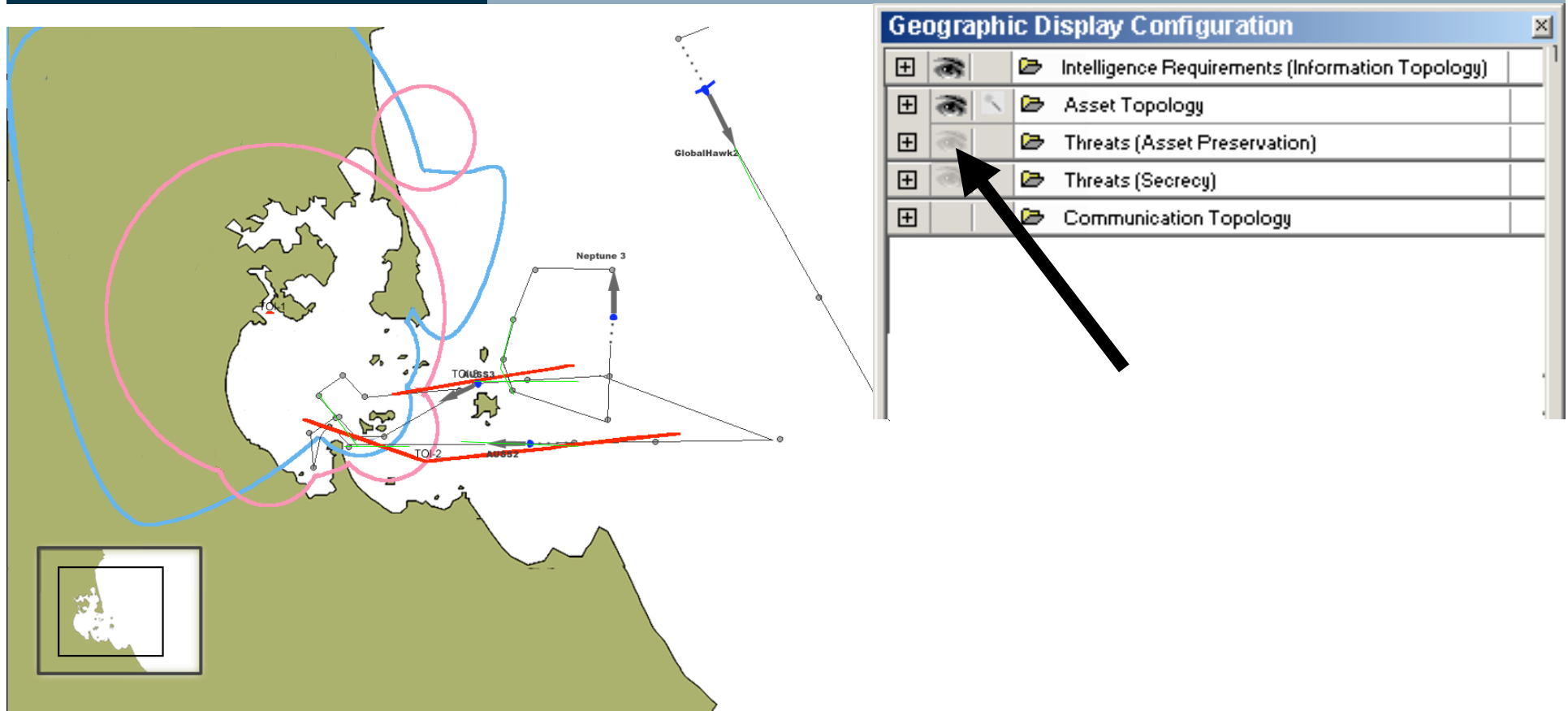
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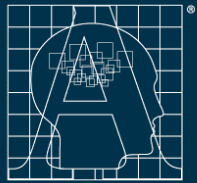




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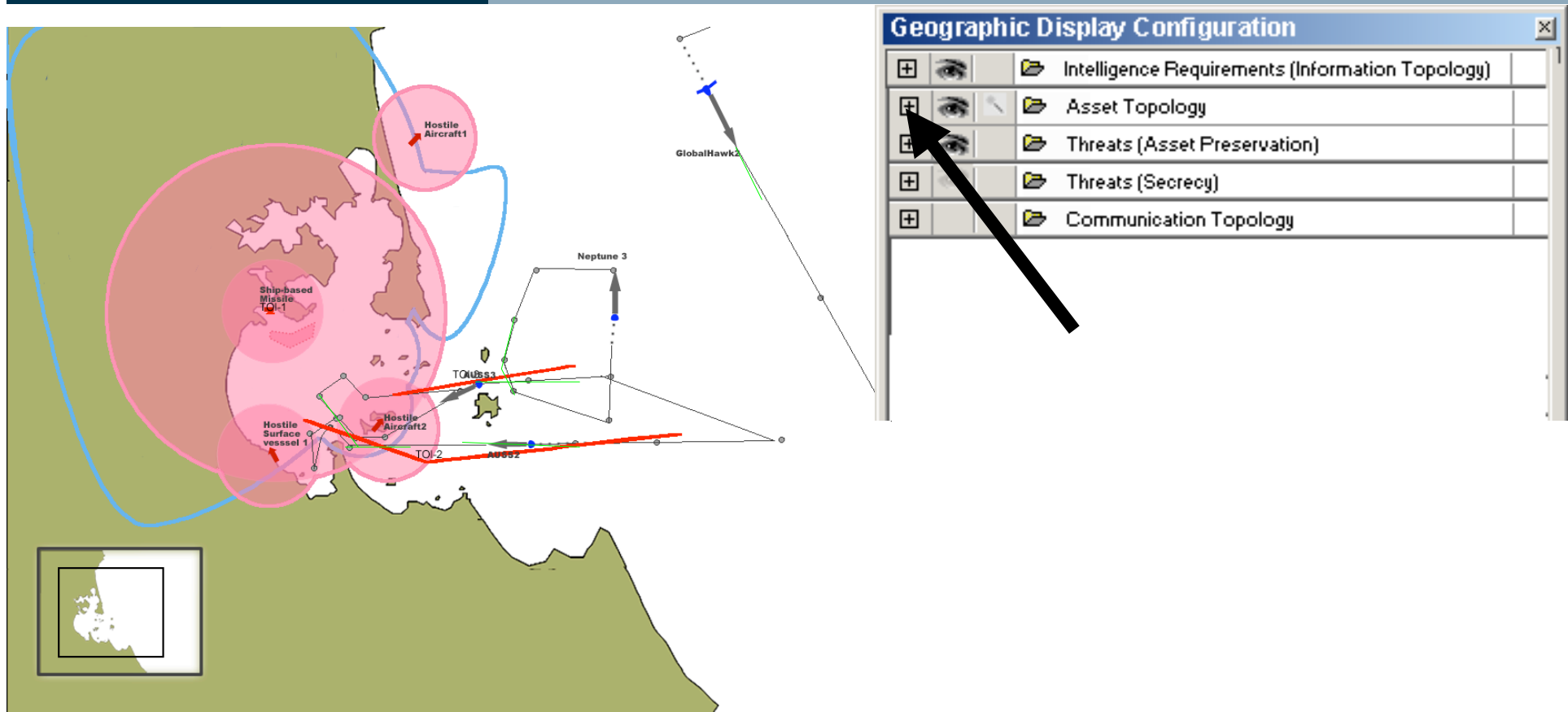
Decomposable Clusters

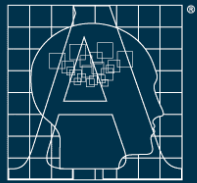




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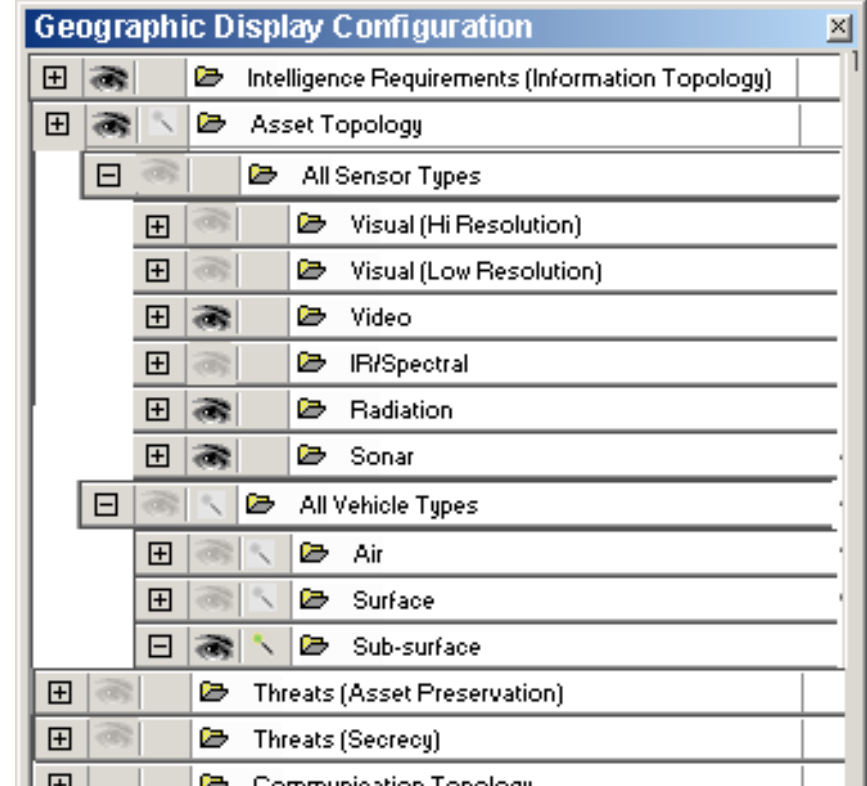
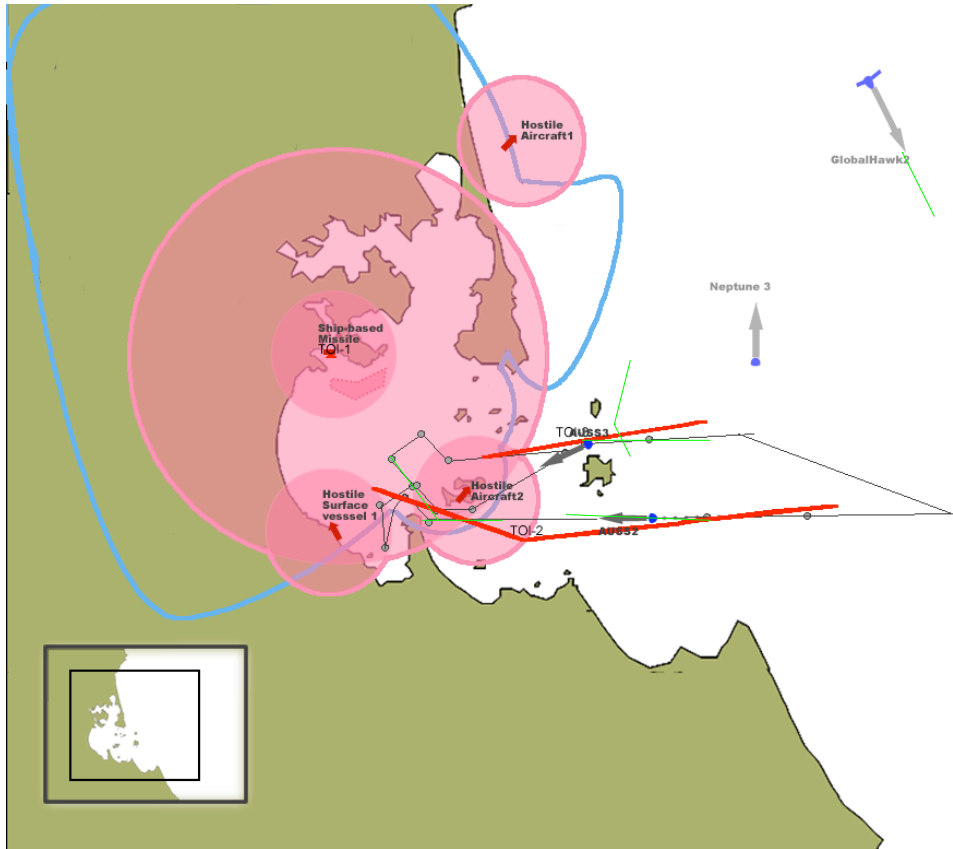
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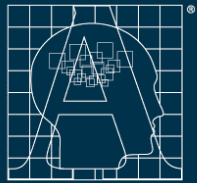




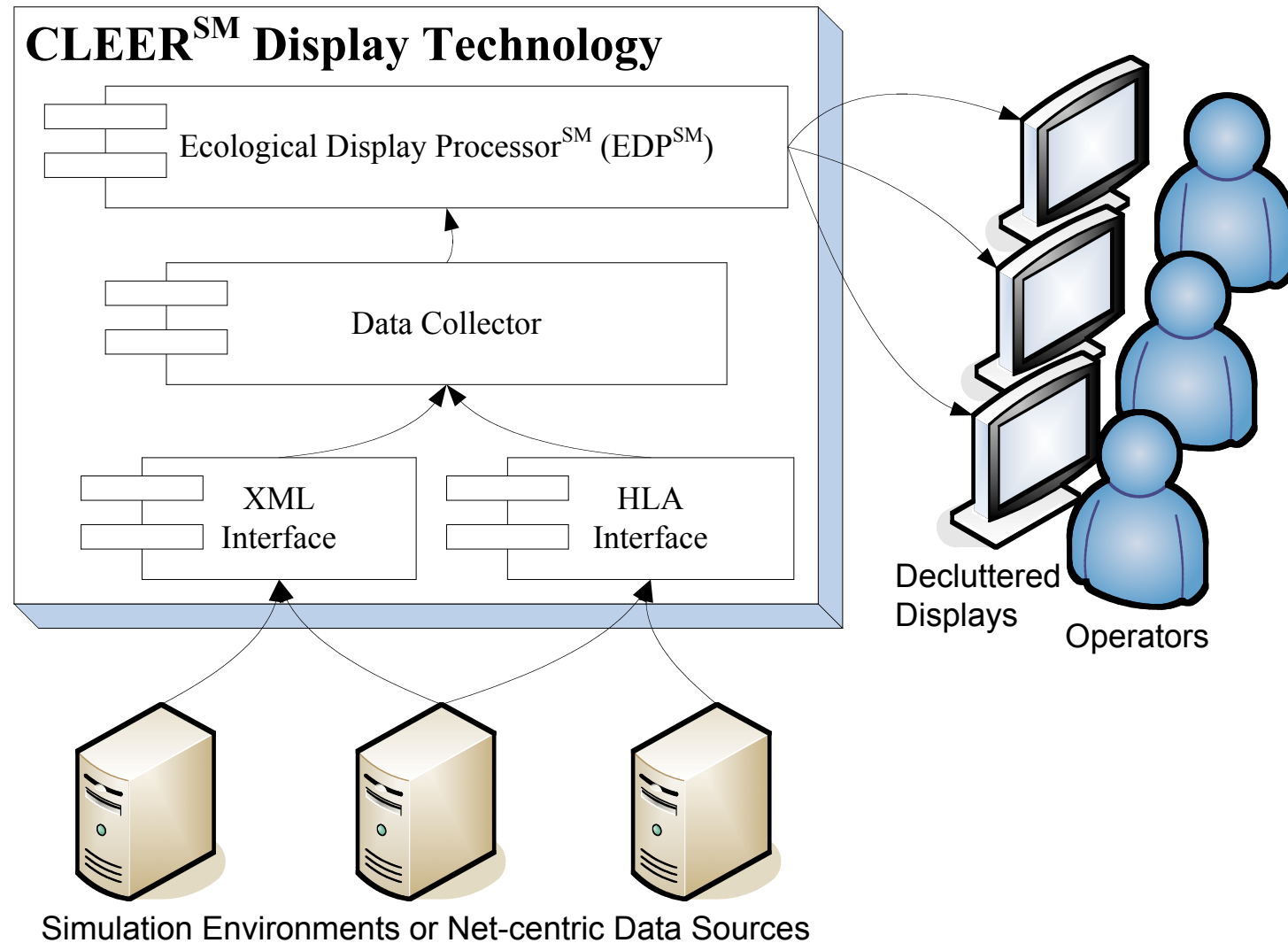
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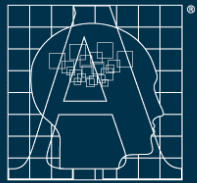
Decomposable Clusters





Creating a Dynamic Display





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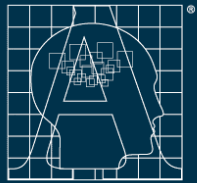
Notional User Interface Layout

Geographic Tactical Display

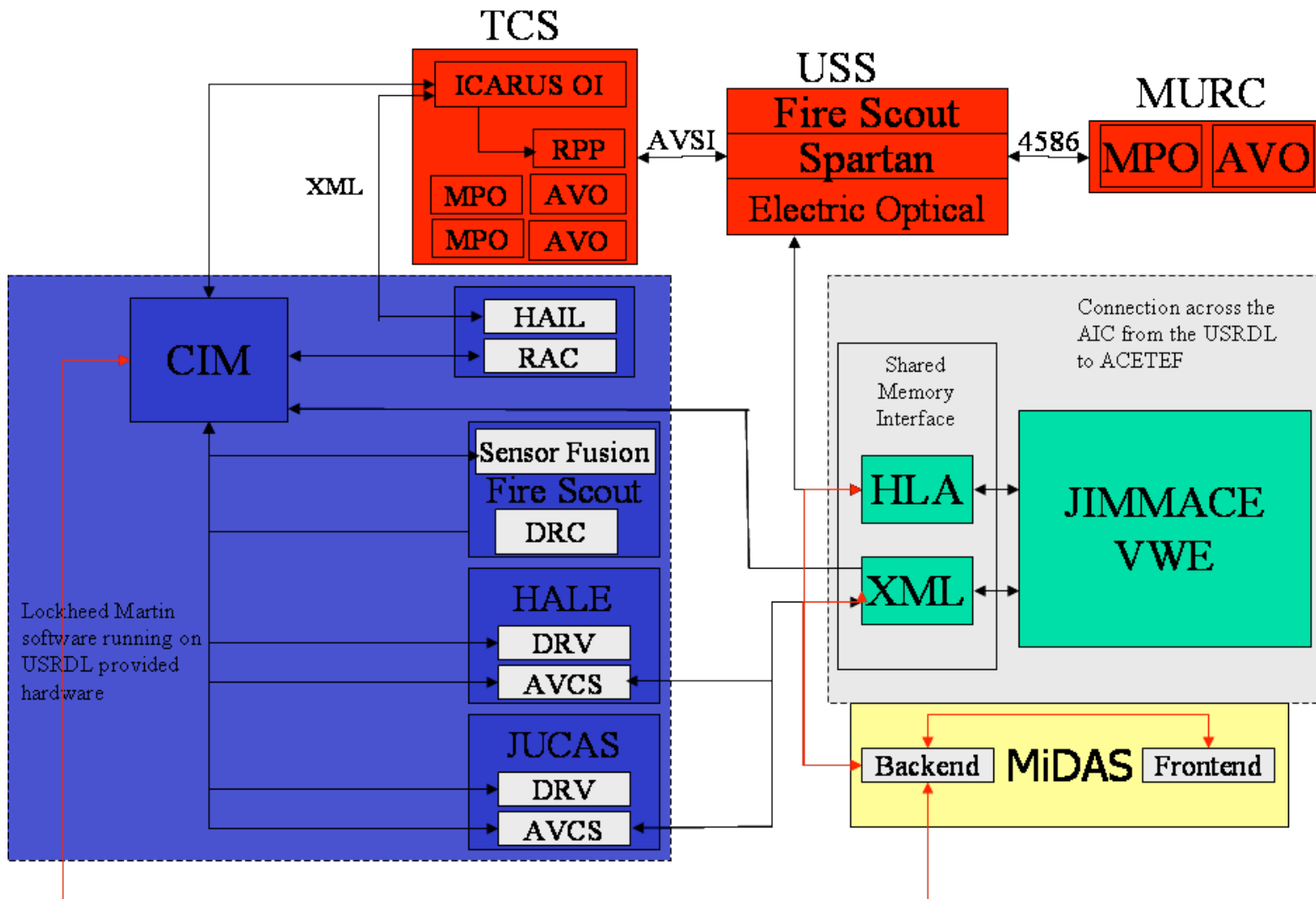
Geographic Display
Configuration tool

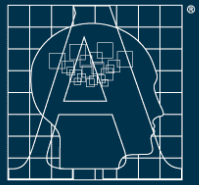
Other
Tools

Timeline & Task Allocation
view of mission plan



Phase II STTR Implementation





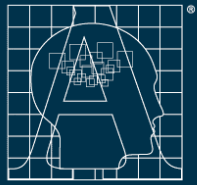
*Human-automation collaboration requires a shared understanding of **the factors that influence the plan...***

*... understanding an automated plan requires a **rich information display** for the mission environment.*

Simplistic Display

Complex Display

*An **ecological organization scheme** supports information presentation along the full range of this spectrum.*



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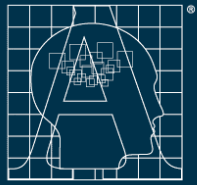
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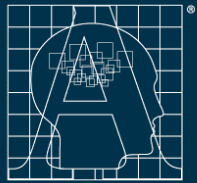
Improving Warfighter Performance in a Reduced Manning Environment through Adaptable Total Ship Computing Displays supporting Effective Collaboration with Intelligent Automation

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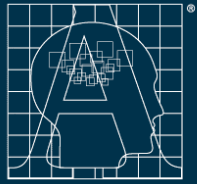
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Questions & Discussion

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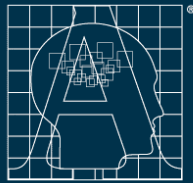
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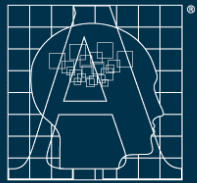
Backup Slides



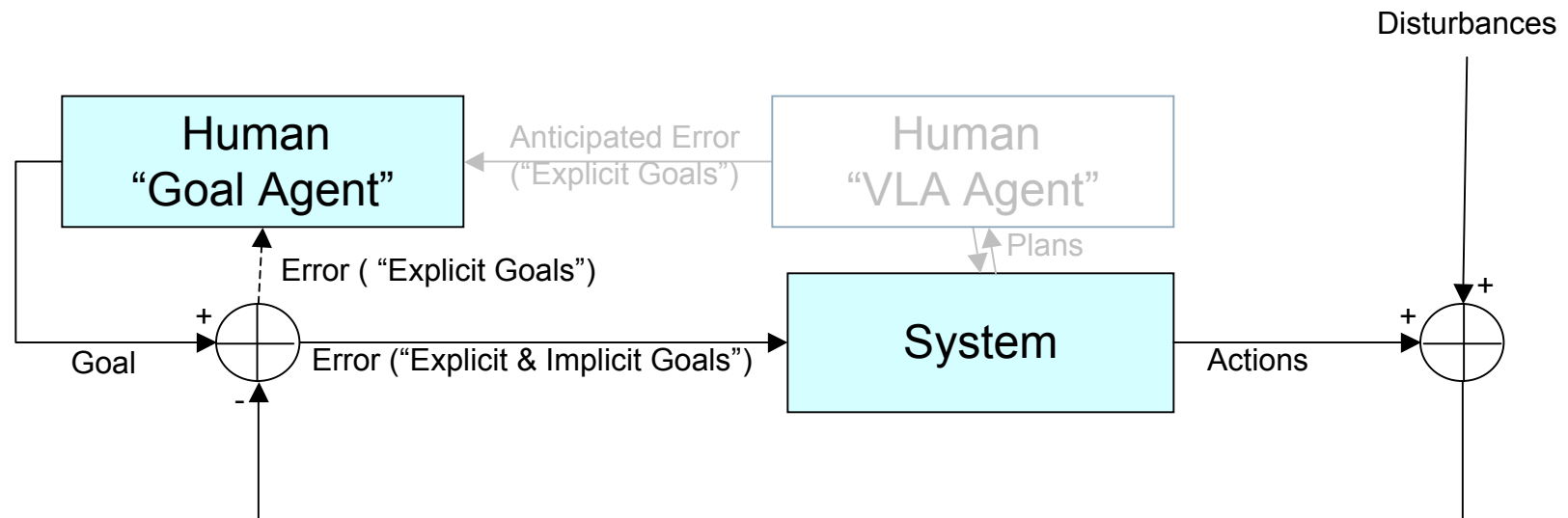
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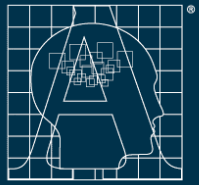
Simplified analogy





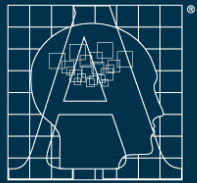
Control Theory Representation





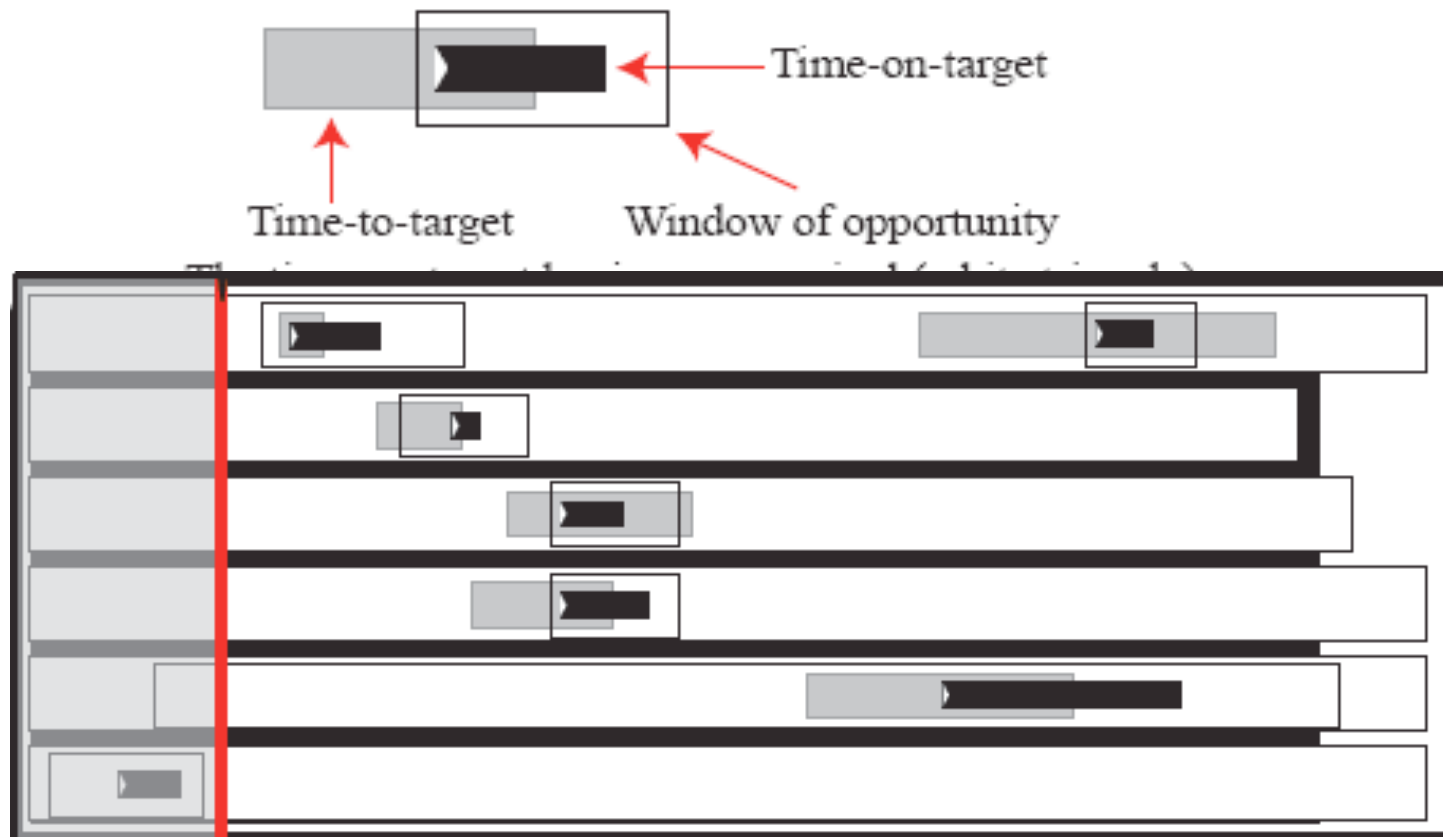
Timeline & Task Allocation

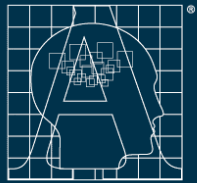
- Concept of Human-Automation Interaction:
 - Automated plans match Tasks-to-Assets based on
 - Information requirements
 - Asset capabilities
 - ...optimization of identifiable constraints and affordances
 - Operator assesses “goodness of fit” for the plan across **space and time**
- Geographic Display supports diagnosis of plans in space.... but....
- **Future Temporal Alignment** is a construct not easily displayed through a geographic display



Timeline & Task Allocation

- Design Challenge 1: “Window of Opportunity”





Timeline & Task Allocation

- Design Challenge 2: “Task Allocation Diagnosis”

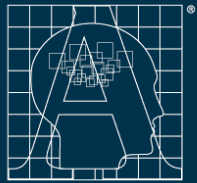


Assigned

Unassigned, compatible

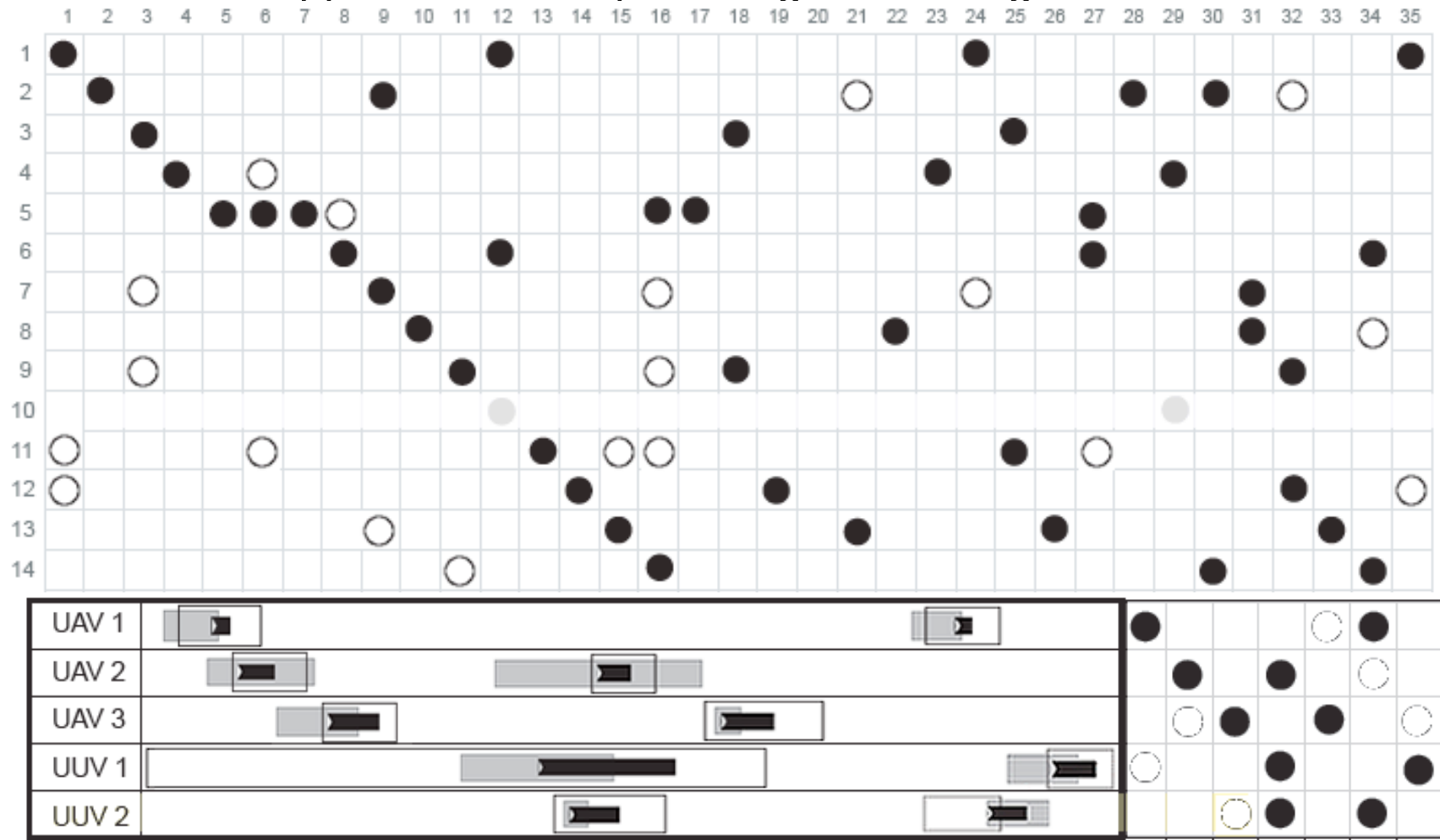
Unassigned, incompatible

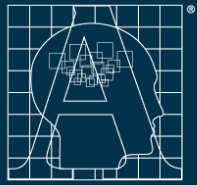
	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7
UAV 1	Assigned	Unassigned, compatible		Unassigned, compatible	Unassigned, compatible	Assigned	
UAV 2		Unassigned, compatible		Assigned	Unassigned, compatible		
UAV 3		Unassigned, incompatible			Unassigned, incompatible		
UUV 1	Assigned					Unassigned, compatible	Assigned
UUV 2	Unassigned, compatible		Assigned				



Timeline & Task Allocation

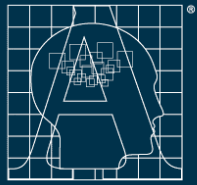
Scalable Approach to Temporal Alignment Diagnosis



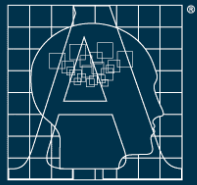


SME Evaluation of Storyboards

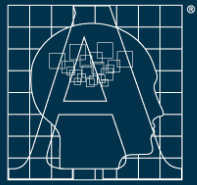
- Focus group evaluation of storyboard concepts:
 - LCDR qualified as TAO, AAWC, SUWC, OOD on DDGs, CGs and FFGs
 - CWO2 qualified as TAO, AAWC, SUWC, OOD on CGs and FFGs
 - OSC qualified as CSC, IDS, MSS, AIC on DDGs, DDs, LHAs, CVNs
- Provided feedback about design concepts, presented in PowerPoint format.
- Concepts presented today are revised displays that attempt to address some of this feedback.
 - (see backup slides for samples of original concept)



- Disagreed with the argument that vehicle paths do not provide enough information to adequately diagnose vehicle activity for an automated system.
 - “Flight and navigation paths are laid out as routes ... aircraft and ships follow those routes until they reach their destination where they stop or orbit/loiter.”
 - “If it is too confusing then he needs to control/monitor less”
- Need better representation of lower levels of details
 - “Navy TACSITS use symbols to discriminate between surface/air/subsurface/land tracks... and don’t rely on text”
- Focused at individual vehicle level control
 - “The operator needs to know the discrete information relative to the vehicle(s) under his control or supervision.”
- Need to consider how concepts would be fielded
 - “...representing them as shaded detection levels is an interesting concept worth exploring but the algorithms aren’t normally available to the shipboard operators”



- Need easy distinction between Air/Undersea/Surface
 - “Blob combined threats to subsurface and air – very different systems incapable of affecting the other. The UUVs don’t need to worry the air defenses nor should the UAVs be concerned with the ASW threats”
- Need to maintain distinction between secrecy and asset preservation
 - “This (separate view of enemy and neutral threat envelopes) is a better display than the grey blob”
- Sensor footprint concept received positive feedback
 - “(We) liked the visualization of the overlapping sensor footprints”
- Highlighting of overlap between threat boundaries and planned paths might be a viable approach
 - “(We) liked (the) threat assessment”



Summary of Results

- Storyboard concepts emphasize monitoring of a mission at a UV “fleet” level
- Emphasis is on:
 - Representing functional relationships
 - Making invisible information visible
 - Grouping information to display “whole system” decomposable into “component part” information
- SME feedback was mixed
 - SME’s inclined to examine mission at individual vehicle level
 - Display of functional relationships received positive feedback
 - Sensor footprint relative to Information need
 - Threat envelope relative to Projected Location
- Phase 1 work provides basis for development and evaluation of dynamic displays in Phase 2